

A SUGGESTED METHOD FOR RATING THE VULNERABILITY  
OF SPRUCE-FIR STANDS TO BUDWORM ATTACK

An important feature of spruce budworm control through forest management is the removal of highly susceptible stands in advance of attack. Such cuttings should result in a substantial reduction in the insect's preferred food supply and favorable breeding conditions, thus greatly decreasing the intensity of budworm attack, thereby keeping damage and loss to a minimum.

It is recognized that stands vary in degree of vulnerability. All who studied the question agree that high concentrations of mature balsam fir constitute the most vulnerable areas. Thus vulnerability appears to be closely associated with the quantity and age of balsam fir, susceptibility to attack lessening with a decrease in the quantitative value of these two factors. For example, a 10-cord per acre balsam fir stand averaging 6 inches in diameter normally is much less vulnerable than one of equal volume but averaging 16 inches in diameter. Vulnerability, then, is largely a function of the volume and diameter of the balsam fir component of a stand. On the assumption that basal area is a more accurate measure of vulnerability than diameter the susceptibility of any particular stand can be expressed as the product of the balsam fir volume component and its average basal area at breast height. Thus the equation would read:

$$S = V \times B.A.$$

S = susceptibility rating

V = balsam fir volume in cords per acre

BA = basal area of the average balsam fir at breast height (3.1416 X radius squared)

For the 10-cord balsam fir stand mentioned above with an average d.b.h. of 6 inches the vulnerability index would be approximately 280.

$$S = 10 \times 3.1416 \times 3^2$$

$$S = 280$$

Similarly the vulnerability index for the stand of equal volume averaging 16 inches d.b.h. would be 1960 or approximately 7 times as vulnerable as the first mentioned stand. To enable ready determination of stand vulnerability the attached Table 1, based on two known balsam fir stand factors -- volume and diameter -- was prepared. According to this table a stand containing 2 cords of balsam fir per acre with an average diameter of 14 inches rates about the same vulnerability as an 11-cord balsam stand averaging 6 inches in diameter. From a practical standpoint the

value 3.1416 can be disregarded since its elimination in no way affects the relative values. The vulnerability ratings thus obtained for the 6-inch and 16-inch stands would be 90 and 64.0 respectively, the same 1 to 7 ratio obtained above. How accurately the formula expresses relative vulnerability must be determined by further study and experience. By determining the cord volume of balsams in a range of size classes, Table 2 showing the vulnerability of balsam for each diameter class was calculated.

The utility of the formula when applied to cruise data depends on the completeness with which the timber tallies were made. There the cruiser records merchantable trees only and makes no tally of defective balsam, only a segment of the vulnerable portion of the stand will be incorporated in the cruise sheets. Application of the formula to such data will result in a serious underrating of the stand's vulnerability. Tallying of cull balsam, therefore, should be made standard procedure in future timber cruises. This would enable vulnerability determination by stand units of varying sizes and delineation of timber properties into zones of varying vulnerability.

It should be borne in mind that other factors than size, age, and volume of balsam fir influence a stand's susceptibility to budworm attack. For example, site quality, stand history, stand vigor, hardwood-conifer ratio, etc., often play a significant role. Nor has allowance been made for white spruce and other species subject to attack by the budworm. When possible an estimate of the influence of these factors should be made and a correction factor applied to the rating obtained through use of the formula. For example, according to the attached vulnerability rating table, a 7-cord balsam fir stand averaging 8 inches in diameter has a vulnerability rating of 350. Let us assume, however, that the stand occurs in an extensive area of mixed growth in which hardwoods comprise 50 percent of the stand. The buffer effects of these hardwoods to budworm attack may justify reducing the vulnerability of this stand by 25 percent. On the other hand for a stand of the same size and volume but growing on a poor site and lacking an admixture of hardwoods or resistant species, a 25 percent increase in the normal vulnerability rating of the stand may be justified. When further research makes it possible to evaluate the effects of these various factors, correction factors can be developed and applied to assure more precise estimates of stand vulnerability.

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Table 1. Numerical ratings for vulnerability of spruce-fir stands to budworm attack

| Average<br>balsam fir<br>stand<br>diameter.<br>(d.b.h.) | Gross balsam fir volume (cords per acre) |     |     |     |     |       |       |       |       |       |       |       |
|---------------------------------------------------------|------------------------------------------|-----|-----|-----|-----|-------|-------|-------|-------|-------|-------|-------|
|                                                         | 1                                        | 2   | 3   | 4   | 5   | 6     | 7     | 8     | 9     | 10    | 11    | 12    |
|                                                         | Vulnerability ratings                    |     |     |     |     |       |       |       |       |       |       |       |
| 6                                                       | 28                                       | 56  | 74  | 112 | 140 | 168   | 196   | 224   | 252   | 280   | 308   | 336   |
| 7                                                       | 38                                       | 76  | 114 | 152 | 180 | 228   | 266   | 304   | 342   | 380   | 418   | 456   |
| 8                                                       | 50                                       | 100 | 150 | 200 | 250 | 300   | 350   | 400   | 450   | 500   | 550   | 600   |
| 9                                                       | 63                                       | 126 | 189 | 252 | 315 | 378   | 441   | 504   | 567   | 630   | 693   | 756   |
| 10                                                      | 78                                       | 156 | 234 | 312 | 390 | 468   | 546   | 624   | 702   | 780   | 858   | 936   |
| 11                                                      | 94                                       | 188 | 282 | 376 | 470 | 564   | 658   | 752   | 846   | 940   | 1,034 | 1,128 |
| 12                                                      | 112                                      | 224 | 336 | 448 | 560 | 672   | 784   | 896   | 1,008 | 1,120 | 1,232 | 1,344 |
| 13                                                      | 131                                      | 262 | 393 | 524 | 655 | 786   | 917   | 1,048 | 1,179 | 1,310 | 1,441 | 1,572 |
| 14                                                      | 152                                      | 304 | 456 | 608 | 760 | 912   | 1,064 | 1,216 | 1,368 | 1,520 | 1,672 | 1,824 |
| 15                                                      | 174                                      | 348 | 522 | 696 | 870 | 1,044 | 1,218 | 1,392 | 1,566 | 1,740 | 1,914 | 2,088 |
| 16                                                      | 198                                      | 396 | 594 | 792 | 990 | 1,183 | 1,386 | 1,584 | 1,746 | 1,980 | 2,178 | 2,376 |

Table 2. Vulnerability rating table for varying numbers of balsam fir by diameter classes

| Tree<br>diameter<br>(inches) | Number of trees       |     |     |     |       |       |       |       |       |       |
|------------------------------|-----------------------|-----|-----|-----|-------|-------|-------|-------|-------|-------|
|                              | 1                     | 2   | 3   | 4   | 5     | 6     | 7     | 8     | 9     | 10    |
|                              | Vulnerability ratings |     |     |     |       |       |       |       |       |       |
| 6                            | 1                     | 2   | 3   | 4   | 5     | 6     | 7     | 8     | 9     | 10    |
| 7                            | 2                     | 4   | 6   | 8   | 10    | 12    | 14    | 16    | 18    | 20    |
| 8                            | 4                     | 8   | 12  | 16  | 20    | 24    | 28    | 32    | 36    | 40    |
| 9                            | 5                     | 10  | 15  | 20  | 25    | 30    | 35    | 40    | 45    | 50    |
| 10                           | 10                    | 20  | 30  | 40  | 50    | 60    | 70    | 80    | 90    | 100   |
| 11                           | 16                    | 32  | 48  | 64  | 80    | 96    | 112   | 128   | 144   | 160   |
| 12                           | 23                    | 46  | 69  | 94  | 115   | 138   | 161   | 184   | 207   | 230   |
| 13                           | 32                    | 64  | 96  | 128 | 160   | 192   | 224   | 256   | 288   | 320   |
| 14                           | 44                    | 88  | 132 | 176 | 220   | 264   | 308   | 352   | 396   | 440   |
| 15                           | 60                    | 120 | 180 | 240 | 300   | 360   | 420   | 480   | 540   | 600   |
| 16                           | 80                    | 160 | 240 | 320 | 400   | 480   | 560   | 640   | 720   | 800   |
| 17                           | 106                   | 212 | 318 | 424 | 530   | 636   | 742   | 848   | 954   | 1,060 |
| 18                           | 147                   | 294 | 441 | 588 | 735   | 882   | 1,029 | 1,176 | 1,323 | 1,470 |
| 19                           | 175                   | 350 | 525 | 700 | 825   | 1,050 | 1,225 | 1,400 | 1,575 | 1,750 |
| 20                           | 217                   | 434 | 651 | 868 | 1,085 | 1,302 | 1,519 | 1,735 | 1,953 | 2,170 |